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4/12/02

The Other Projects

PAC meeting
FNAL
April 12, 2002

Franco Bedeschi
INFN-Pisa

Outline:

- Brief status of CDF
- Other Projects for Run 2B

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Status of CDF

- Detector:
  - All systems installed and commissioned
    - ISL will be fixed during the next accesses this summer
- DAQ and trigger:
  - Running physics trigger table with > 100 trigger paths since February
    - **New** SVT very successful
  - Typical running conditions from this week:
    - L1: 3.5KHz, L2: 200 Hz, L3: 20 Hz
- Data processing:
  - Reconstruction farm keeps up with data logging
  - Physics groups skim data:
    - Observe signals from low and high pt triggers: ψ, D, B, W, Z
    - Some preliminary results expected for Amsterdam this July

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W and Z's

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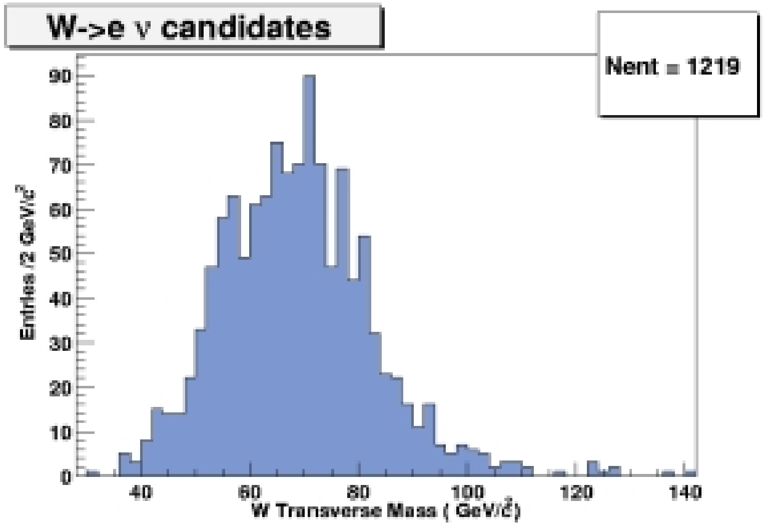
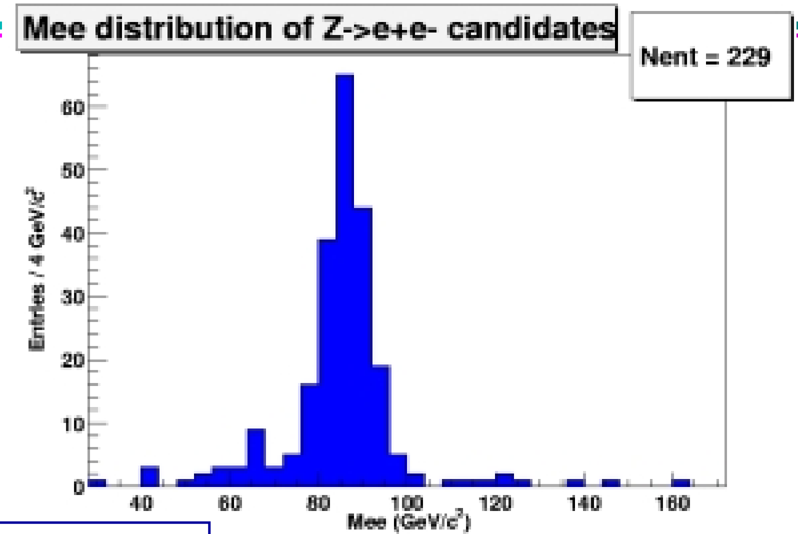
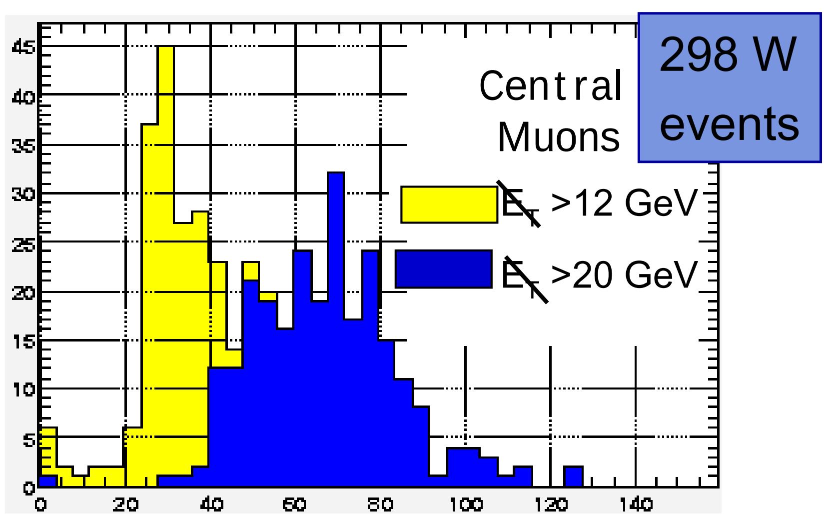
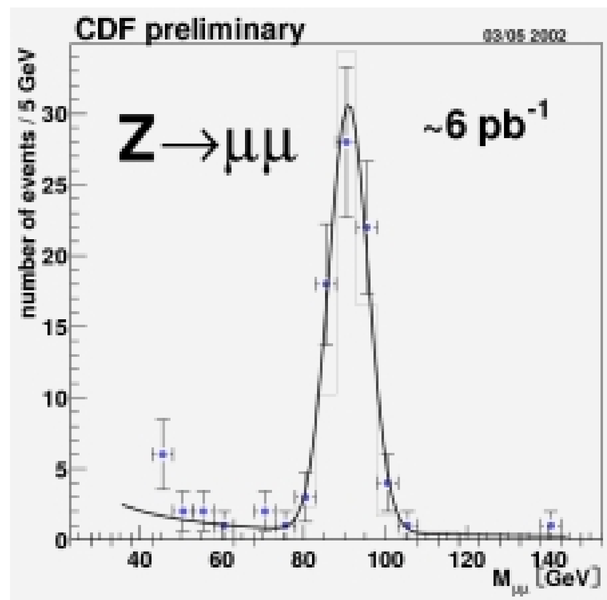




From 3.65 pb-1





ration

CDF: J/ψ   μ⁺μ⁻

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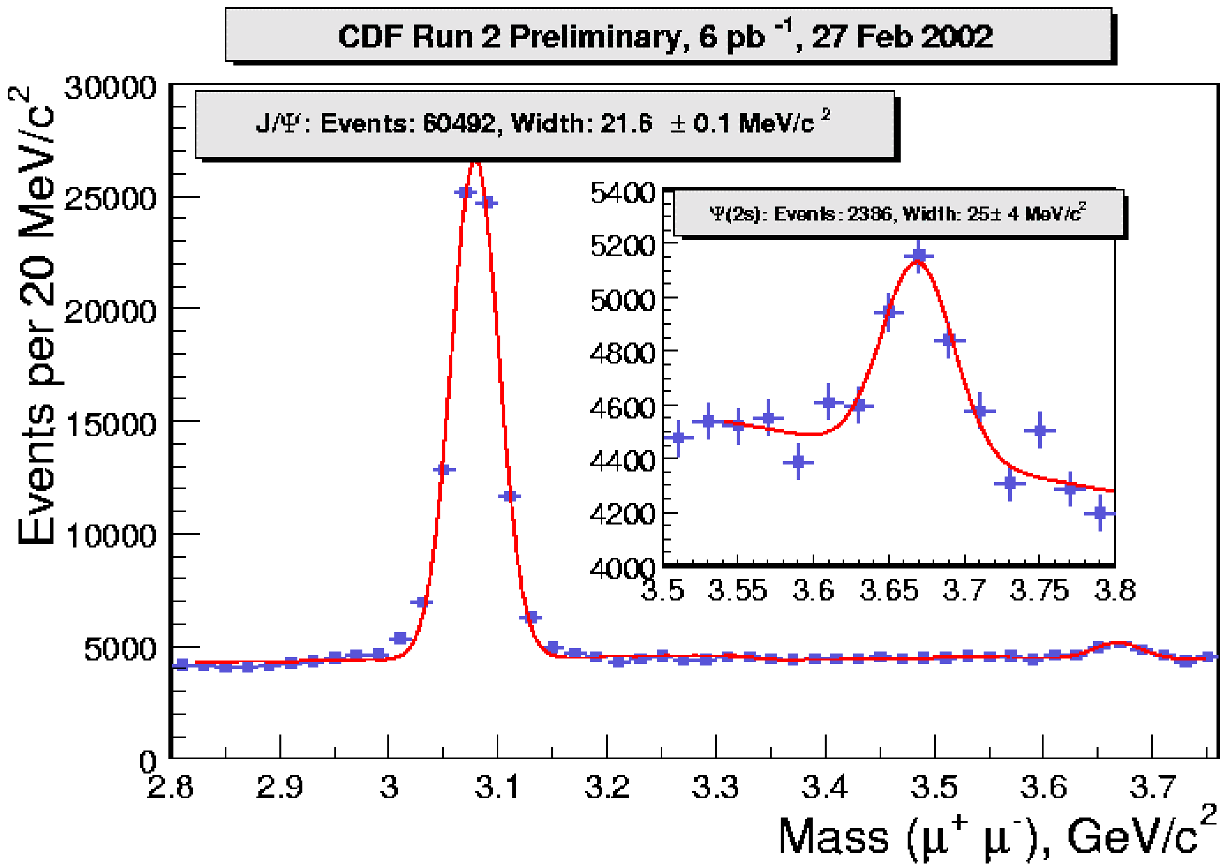

- Clear J/ψ signal
  - CMU or CMX
    - ~ 60,000 ψ's
    - σ = 21 MeV/c^2 (16 with SVX II)
    - J/ψ x-section ~9nb as expected

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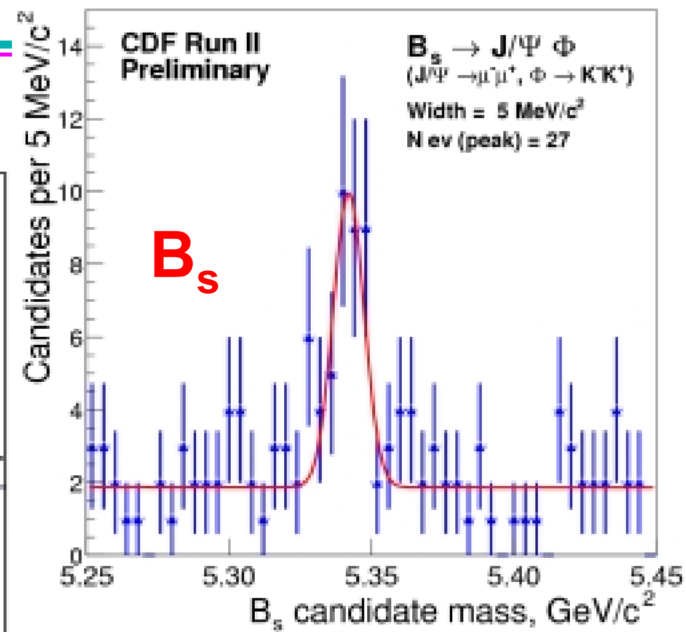
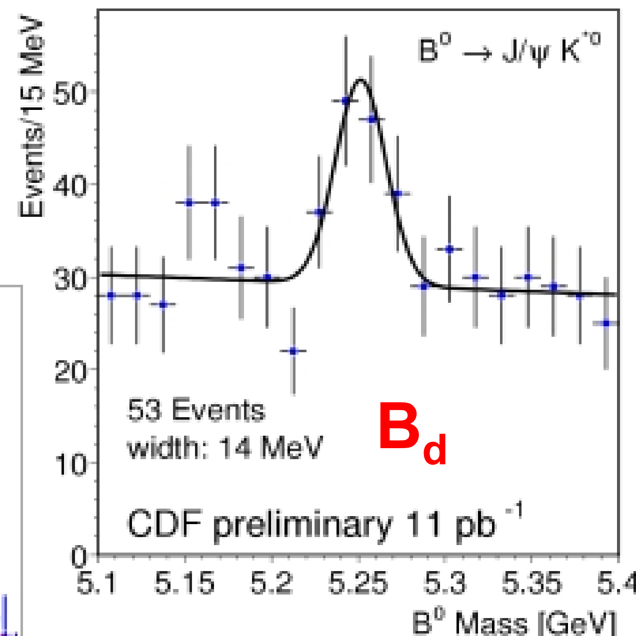
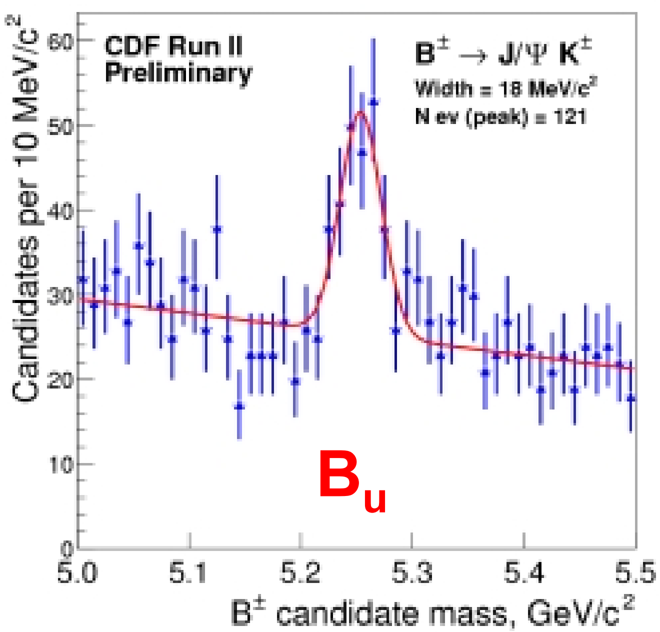
First B signals







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So much Charm!!!

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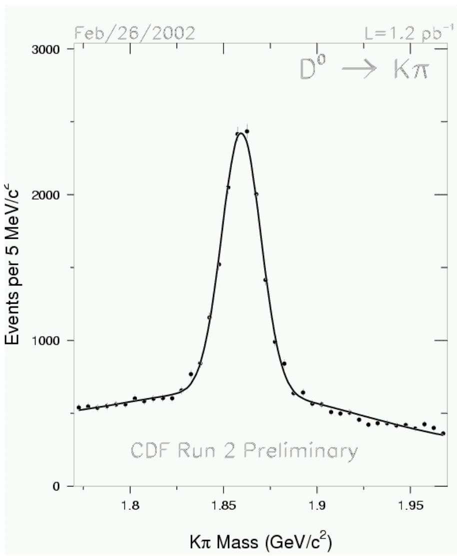
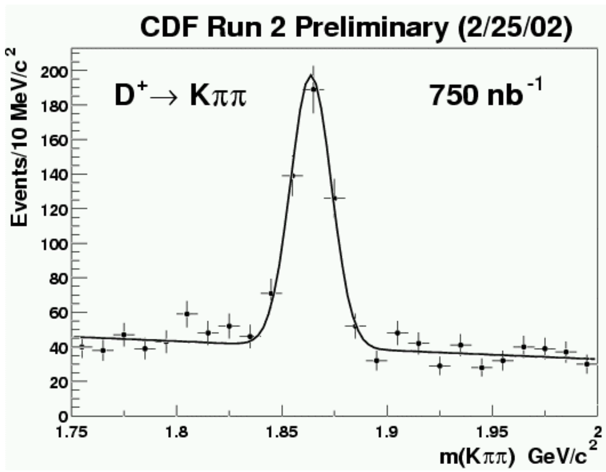
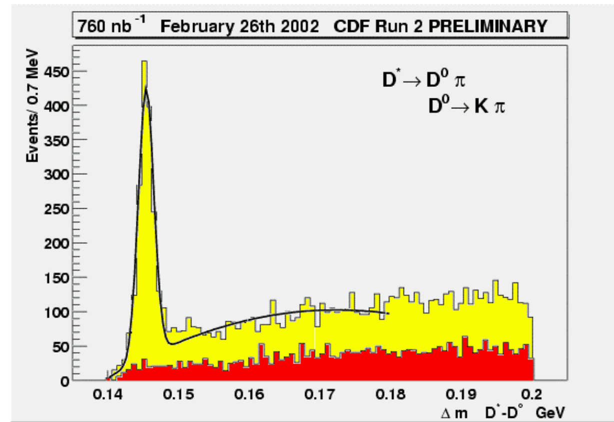
- Getting much more charm than expected with SVT!!!







$D^0 \to K^-\pi^+$ yields:

$50\ pb^{-1}$	$2\ fb^{-1}$	E791	FOCUS	$\Upsilon(4S)/100\ fb^{-1}$
500K	20M	40K	120K	1M

Large yield, but poor PID, biased trigger, prompt & secondary charm……….
Need to understand how to make best use of it

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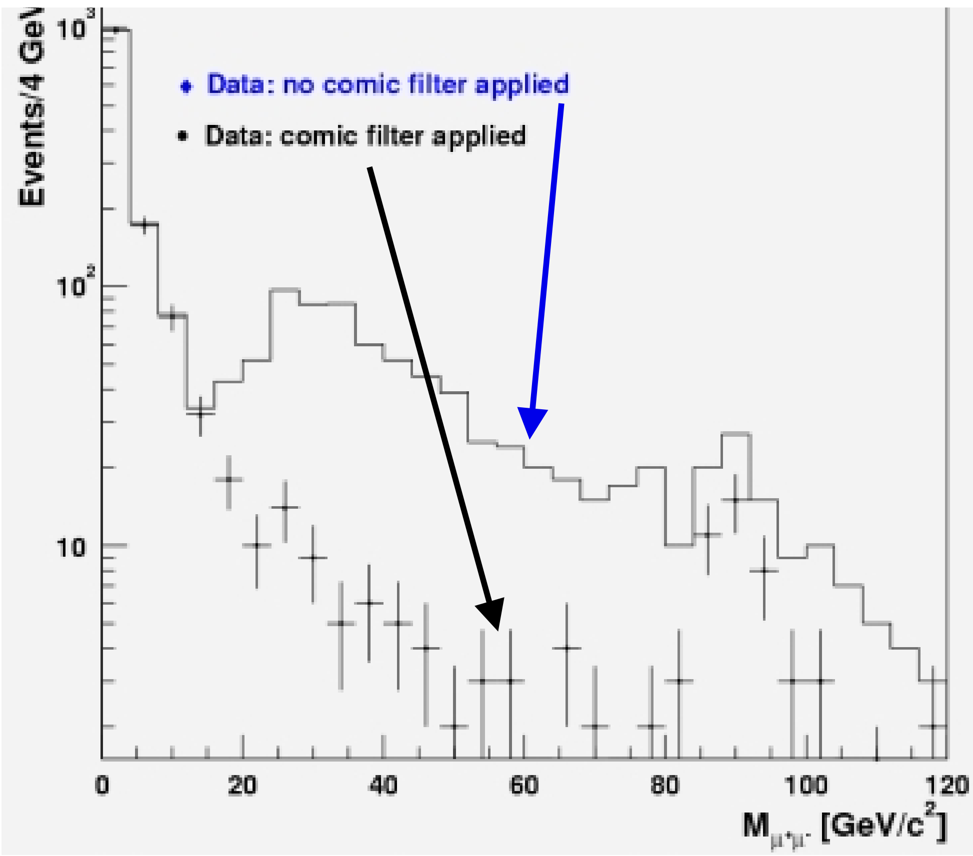
The Other Projects

- EM calorimeter timing
  - Enhance γ physics
- Trigger and DAQ
  - Deal with bottlenecks that become a problem at high luminosity
- In the spirit of “full disclosure” describe possible special COT maintenance

EM Calorimeter Timing

- Cosmic background removal is essential (e.g. Z $\mu^+ \mu^-$,)
- Hard to do with γ Need for EM calorimeter timing



- Calorimeter timing currently implemented only on hadron calorimeters

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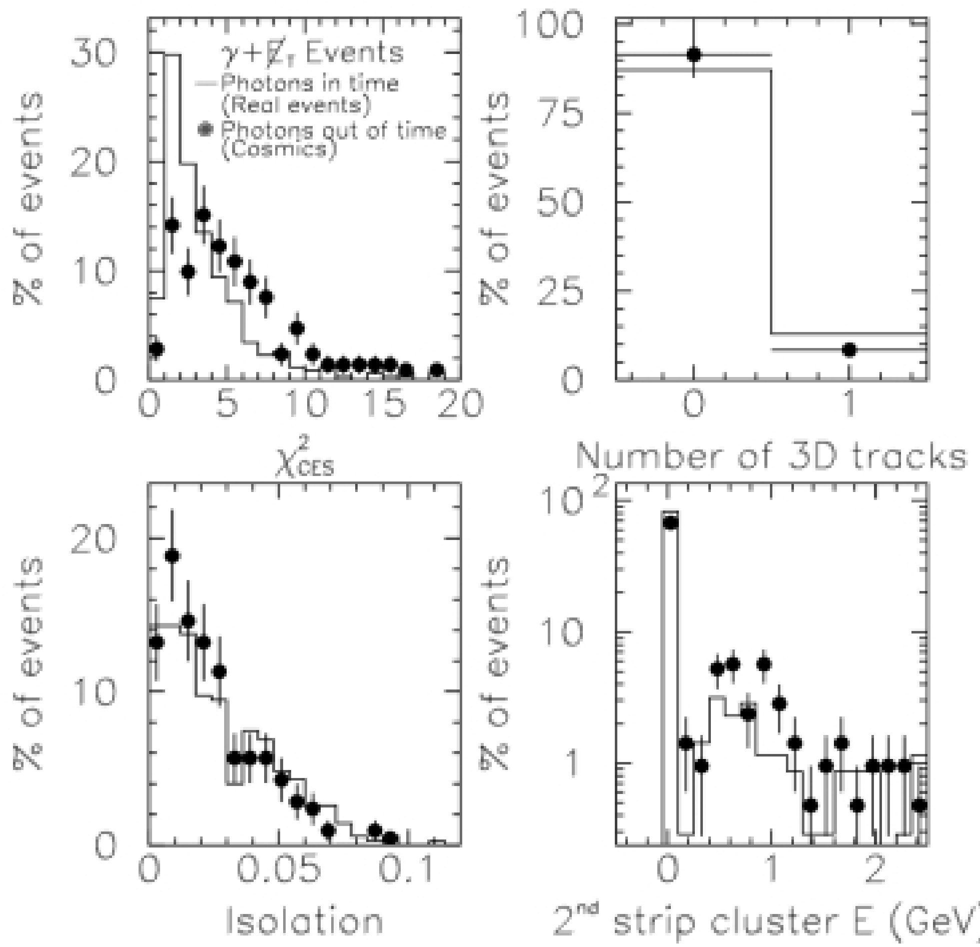
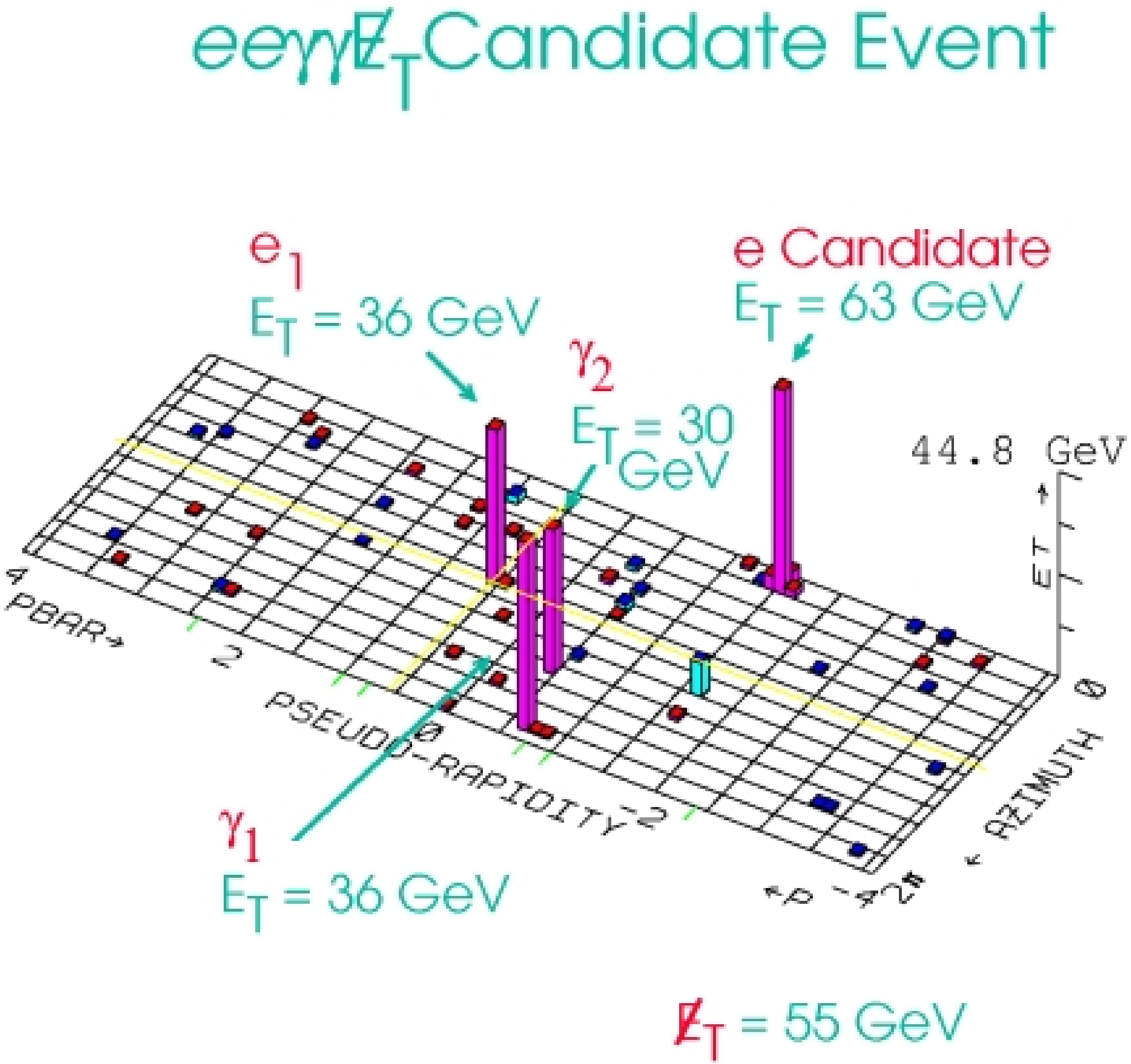
EM Calorimeter Timing

- In γ + MET events hard to find a good handle to remove cosmic backgrounds
  - Figure shows comparison of some natural discriminating variables for "in time" and "out of time" data
    - No big difference between distributions



EM timing

- Physics Motivation:
  - Important for SUSY, LED searches which rely on photons
  - Important for studies of W/Z γ production
  - Important for any other study involving γ
  - Our $ee\gamma\gamma\not{E}_T$ had 2 EM object missing timing information!



EM timing

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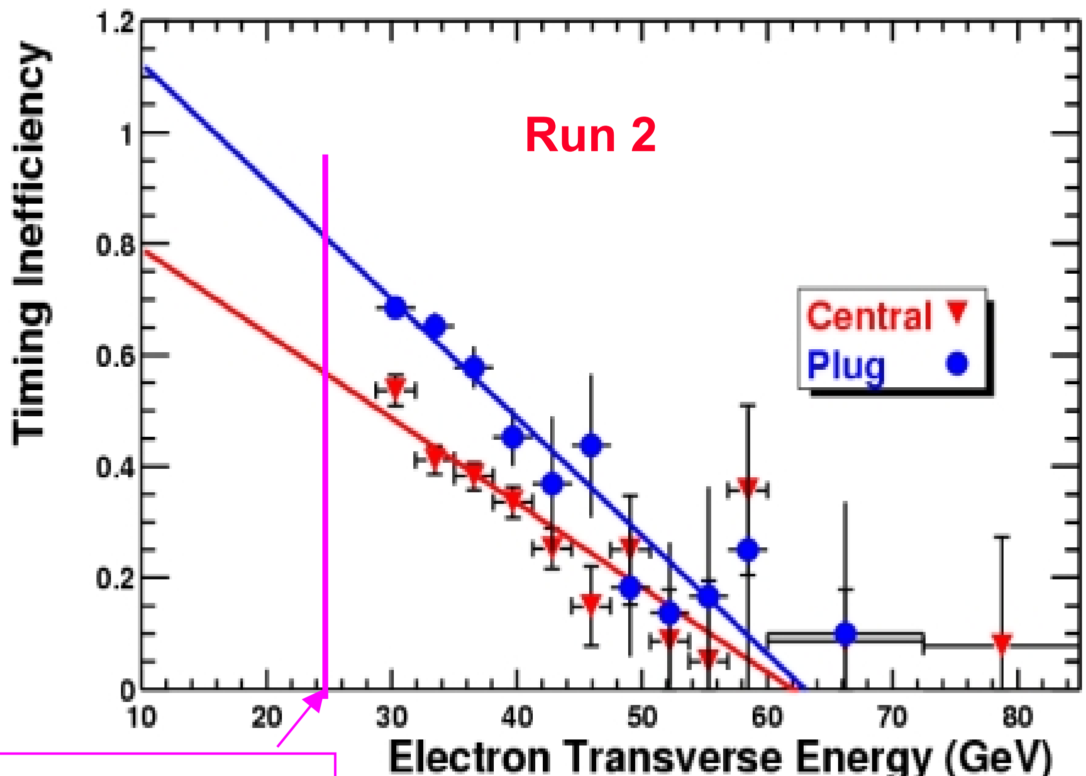
- Currently only Hadronic Calorimeters have timing instrumented
  - EM shower needs to leak into Hadronic section to be timed → inefficiency!



Run II γ +MET
Trigger threshold

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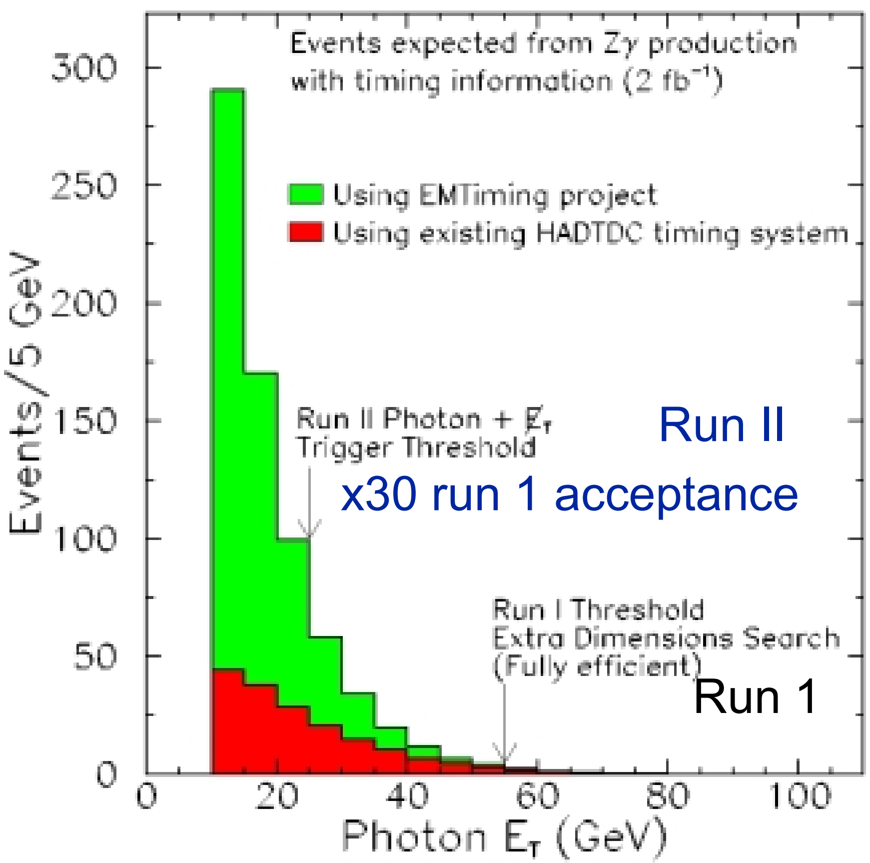
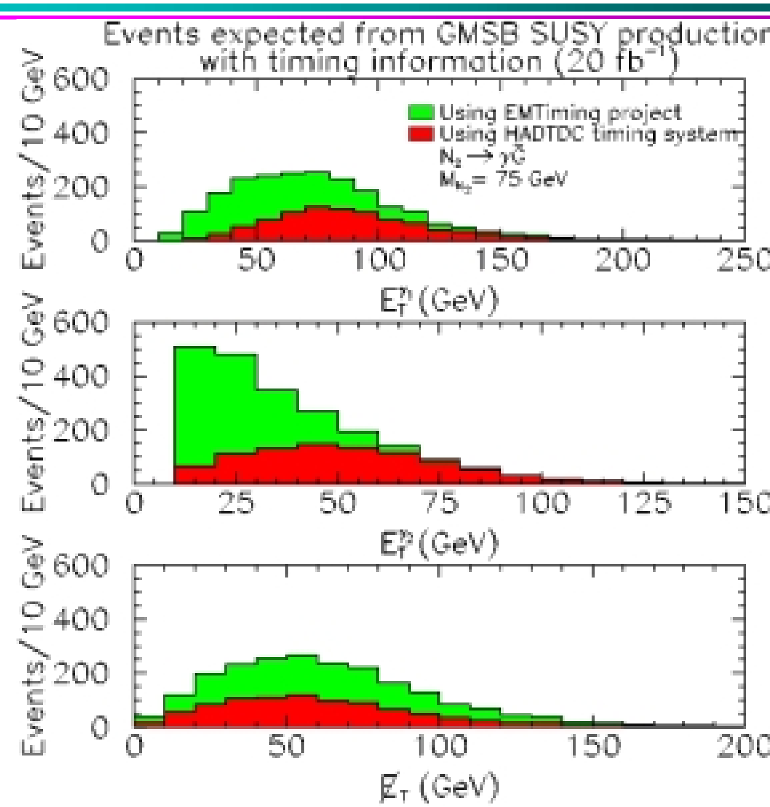
EM Calorimeter Timing

- Examples:
  - EWK physics: Wγ,Zγ production
  - SUSY searches: $\tilde{N}_2$ γ $\tilde{G}$





Need good containment of shower to have reliable efficiency calculation

- No EM timing   Higher threshold

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EM Timing

- Solution:
  - Add TDC timing to EM calorimeters: Central and Plug
    - Minimal R&D
    - M&S cost ($ 220 K with spares + $ 30 K contingency) would be covered by University grants and INFN funds
    - Project is manpower intensive (est. 336 man-days)
      - **CEM PMT base modification and cabling**
      - **Much would be done with non-Fermilab techs and/or physicists**
  - Descoped version:
    - Add timing only to Plug EM which does not require PMT base modification
- Detailed study of costs and installations done
  - Confident to discuss it next week at Director's Review

Trigger and DAQ

- Current planned trigger optimized for 1x10^{32}
- Current DAQ/Trigger limits exceeded @ 4x10^{32} even dropping all B physics

  L2 rate >> 300 Hz
- Multiple interactions may increase expected rates significantly relative to this current estimate (396 worse)

Dataset	L1 (nb)	L2 (nb)	L3 (nb)
More J/y --> m+ m-	100	50	10
J/y --> m+ m-	400	25	5
ee, em, mm	950	162	47
Radiative/Electronic B decays	8,000	30	6
J/y --> e+ e-	18,000	100	6
Bd --> p+ p-	252,000	360	8
Continuum dimuons M > 5 GeV	(overlap)	8	1
Rare B --> mm X	(overlap)	18	6
Lepton + displaced track	(overlap)	91	50
B(s) --> D(s) p	(overlap)	200	100
B only triggers	**279,450**	**1,044**	**239**

Triggers involving XFT tracks are the ones most affected

- 70% of non-B triggers

Dataset	L1 (Hz)	L2 (Hz)	L3 (Hz)
Total rate (@1x10^{32})	**38,282**	**246**	**56**
B only rate (@1x10^{32})	27,945	104	24
Other trigger rate (@1x10^{32})	**10,337**	**142**	**32**
Total rate (@4x10^{32}) Hz	**153,128**	**985**	**222**
B only rate (@4x10^{32})	111,780	418	96
Other trigger rate (@4x10^{32})	**41,348**	**568**	**127**
Current assumed limits (Hz)	**40,000**	**300**	**75**

Dataset	L1 nb	L2 nb	L3 nb
Zero-bias	10	10	10
Minimum bias	10	10	10
MET + 2 jets	200	90	30
Two hi-p T iso. tracks	**400**	**10**	**1**
Diffraction	400	23	23
High-E T central electron	**1,200**	**115**	**25**
PEM +MET	1,300	70	10
High-p T central muon	**2,550**	**200**	**8**
High-p T b jet	4,300	200	41
Z --> bb	5,700	32	3
Di-τ	6,300	55	5
Single-tower 5	27,000	5	5
jet-70	27,000	12	6
High-E T isolated photon	27,000	100	29
High-E T photon w/o iso	(overlap)	1	1
e + track (no e isolation)	(overlap)	1	0
Low-E T photon	(overlap)	3	2
three EM	**(overlap)**	**5**	**4**
Super high E T EM cluster	(overlap)	5	2
SS/OS backup dataset	(overlap)	7	3
Low-E T isolated di-photons	(overlap)	8	3
photon+muon for charm	(overlap)	10	5
jet-50	(overlap)	18	9
Inclusive MET	(overlap)	20	5
High-E T di-photon w/o iso	(overlap)	20	8
jet-100	(overlap)	27	14
jet-20	(overlap)	30	16
τ + MET	(overlap)	36	5
SS/OS dijets	(overlap)	39	10
MET + 2 b-tags	(overlap)	40	3
Ultra high-E T photon	(overlap)	40	4
(e or μ) + isol. track	**(overlap)**	**52**	**9**
W/Z + Higgs	(overlap)	90	1
med-E T photon + 2 jets	(overlap)	(overlap)	2
W --> e ν (no track)	(overlap)	(overlap)	(overlap)
L3-tagged datasets	(overlap)	(overlap)	(overlap)
High multiplicity	n/a	n/a	n/a
tt --> jets	(overlap)	5	5
Total (other)	**103,370**	**1,419**	**317**

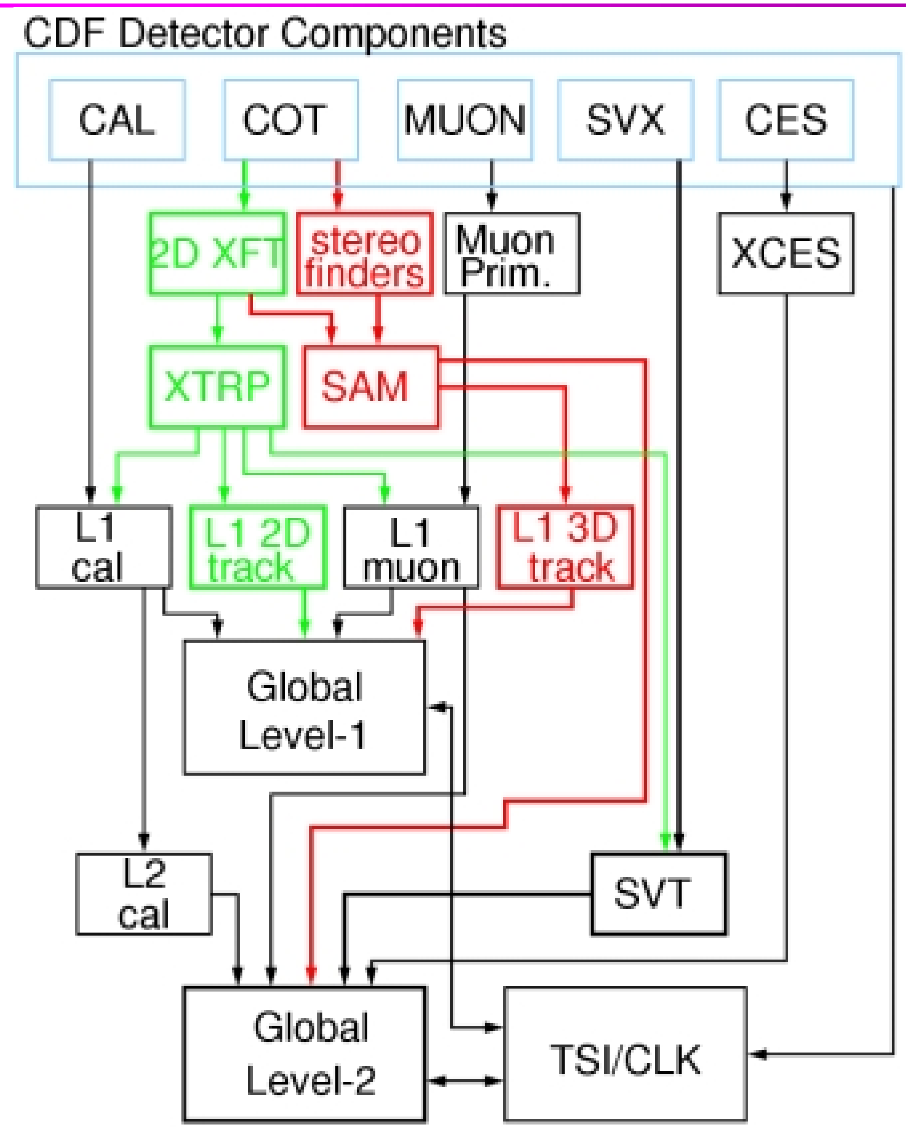
Trigger and DAQ

- Do not have enough operational experience to identify with certainty all bandwidth requirements/bottlenecks, however we have been requested to report now all possible needs for Run 2B upgrades.

- L1 tracking triggers (see later) reduces L1 and L2 rates
  - Include stereo SL7 in XFT to provide 3D information
- Improve speed of L2 decision boards
  - More sophisticated L2 decisions
- Improve readout speed of DAQ boards
  - Current TDC's most likely bottleneck especially if high occupancy
- Upgrade ATM switch (see Pat's talk)

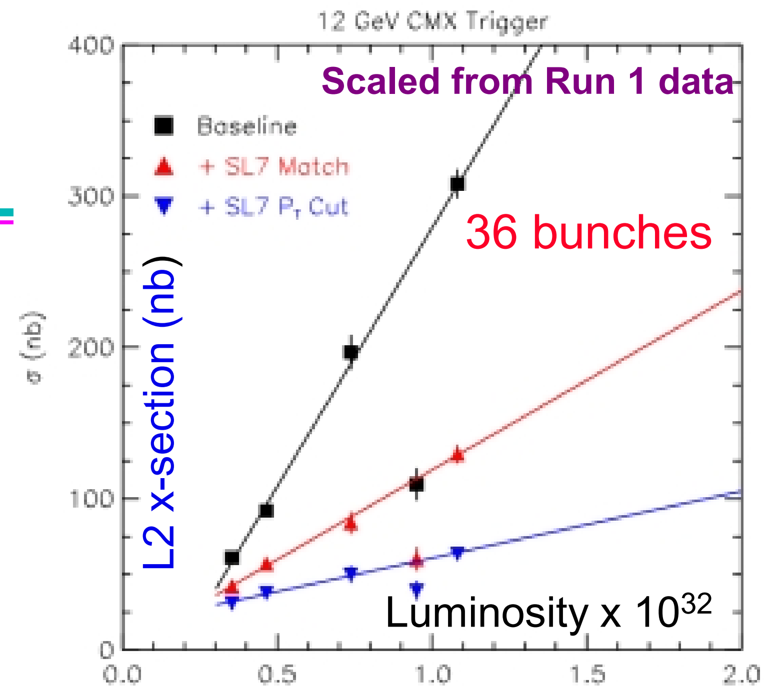
3D tracks @ L1

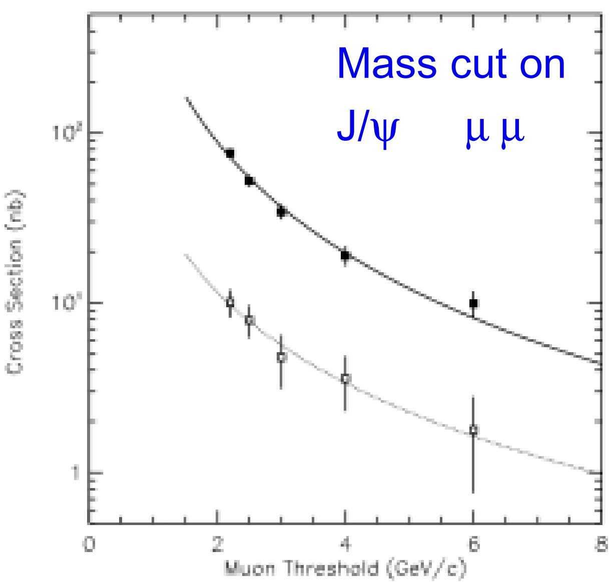
- Need 3 type of boards:
  - Stereo finders (18 boards)
    - Finds stub in stereo layer
    - Very similar to R-ϕ version
  - Stereo Association Modules (12 boards)
    - Associates stereo stub to R-ϕ track
    - Pass 3D tracks to L2
  - L1 track trigger (1 board)
    - Allows multi-track trigger based on 3D information
- Note that 3D pointing to electrons and muons is possible only at L2

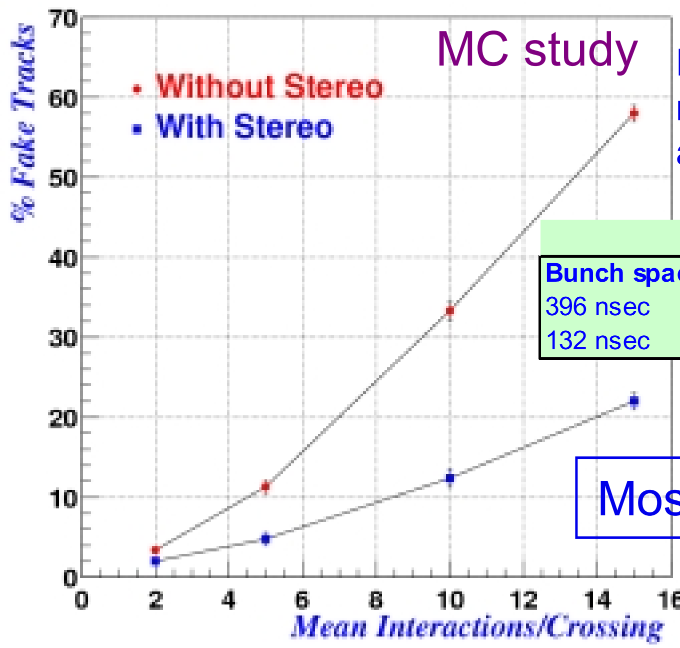


3D tracks @ L1

- Multiple interactions increase fakes in XFT tracks
  - Adding stereo SL7 helps reduce fakes (L1 & L2 [e.g: **e, μ, SVT**])
  - Pointing in 3D improves lepton matching (L2)
  - Invariant mass cut (L1 and L2) helps in several cases
    - e.g. J/ψ μ μ







Results from MC study using multiple MB events overlapped to associated top production

	Luminosity x 10^{32}			
Bunch spacing	**0.5**	**1**	**2**	**5**
396 nsec	1.5	2.9	5.8	14.6
132 nsec	0.5	1.0	1.9	4.9

Most fakes are at high pt

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3D tracks @ L1

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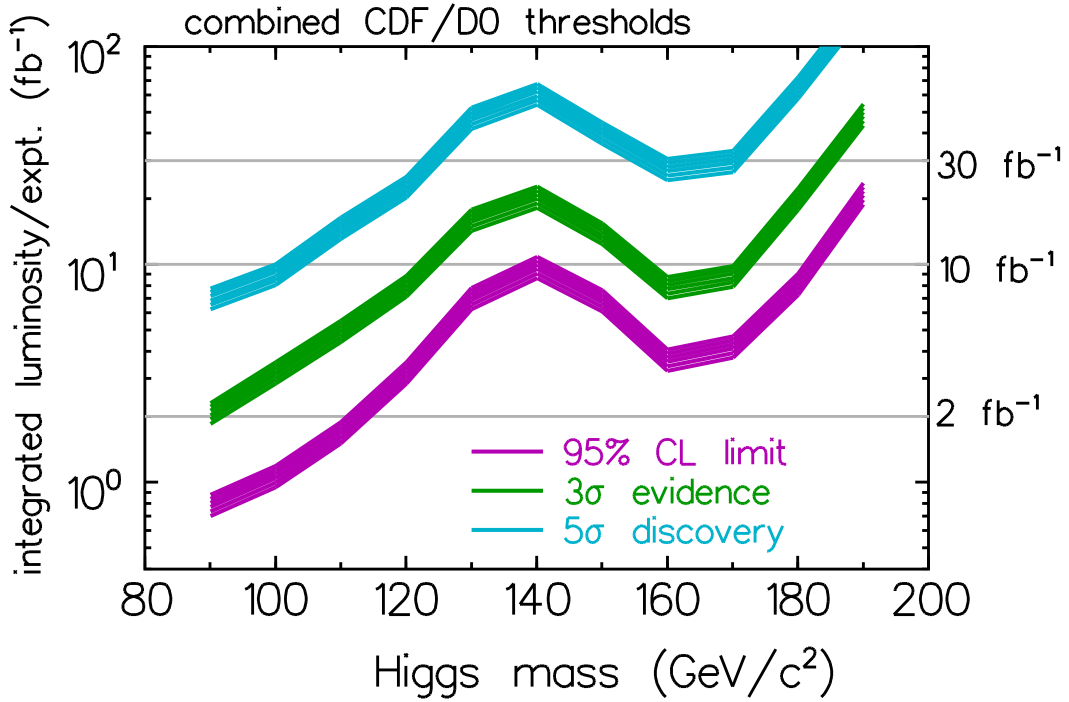
- Higgs Working group report on the Tevatron reach for Higgs is based on the assumption of 100 % trigger efficiency
- Any signal loss at trigger level is directly translated into a decrease in our Higgs reach



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3D tracks @ L1

- Cost of the project:
  - M&S ~ $515 K including 25% contingency + $ 30 K (L1 track board)
- Manpower:
  - Non-Fermilab:
    - 1 senior tech year at OSU-$35k
    - 1 engineer at Illinois-$100K
  - Fermilab;
    - Techs for small amount of cable installation on detector
- Risks is low:
  - No interference with other upgrade projects
  - Boards can be installed at any time
  - Project is a small extension to board already made and operational now
- Costs to be covered with NSF MRI's and University grants

L2 processors

- Do not know yet if absolutely needed, however:
  - Concerns about maintenance of Alpha CPU’s
    - Commercially available products preferred
    - Infrastructure allows easy replacement
  - Concerns about L2 bandwidth
    - Better L2 speeds allow for more sophisticated triggers
- Cost would be limited: ~ $ 100 K
- No interference with other upgrade projects
  - Boards can be installed any time

TDC replacement

- TDC's are currently the most likely bottleneck for DAQ speed
  - Other modes of readout are being pursued, but have so far not been successful. So far readout rate < 300 Hz, consistent with Run IIA specs
  - Readout speed determined by slowest TDC
  - TDC readout speed related to chamber occupancy
    - Now 2x larger than expected
    - Will get worse with more interactions/crossing
- Cost of replacement:
  - M&S ~ $ 500 K with 25% contingency
- Labor:
  - 1 Engineer-yr: ~ $ 100 K
  - 2 techs-yr: ~ $ 50 K
- No interference with other upgrade projects
  - Boards can be installed any time

Cost Summary

Project	M&S cost	Labor
EM Cal. timing	$ 250 K	336 man-days
3D tracks@ L1	$ 545 K	$ 135 K
L2 boards	$ 100 K	???
TDC boards	$ 500 K	$ 200 K

Inner COT layers

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- 2 inner COT SL have large occupancy at high luminosity
  - Implications on trigger and offline analyses not fully understood yet
  - Quantitative assessment of the effect of deadening the end sections of SL 1 and 2 is not yet established
- Do not want to touch the COT if at all possible, however should be prepared to do “special maintenance” if impact on physics is large
- At this time we think that this should NOT be part of the DOE baseline upgrade

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Summary (1)

- CDF Run 2A detector performing very satisfactorily

- We have identified additional projects that we would like to do by Run 2B:
  - EM timing is a major improvement to our γ physics program
    - Has minor impact on lab/DOE resources
    - Possible funding/interested collaborators identified
  - Upgrade L1 tracking to 3D adds significantly to the robustness of our tracking triggers (strong feature of CDF!)
    - Negligible impact on lab/DOE resources
    - Possible funding/interested collaborators identified

Summary (2)

- We may need to upgrade L2 decision boards and TDC's to cope with expected high Pt trigger rates > 300 Hz at L2
  - More operational experience needed, but these are likely bottlenecks
  - If we have to decide now they should be in the baseline upgrade
- All proposed trigger/DAQ upgrades become even more important if a decision is made not to go to 132 ns bunch spacing

Summary (3)

- The people currently interested in these upgrades are not involved in any of the ones described by Pat
- We are trying to use only non-DOE funds for the projects listed in this talk
  - PAC support is essential to give us a chance at getting this additional funding